IN THE UNITED STATES DISTRICT COURT
FOR THE NORTHERN DISTRICT OF OKLAHOMA

STATE OF OKLAHOMA, ex rel,	§
W. A. DREW EDMONDSON,	§
in his capacity as ATTORNEY GENERAL	§
OF THE STATE OF OKLAHOMA,	§
and OKLAHOMA SECRETARY	§
OF THE ENVIRONMENT	§
C. MILES TOLBERT, in his capacity as	§
the TRUSTEE FOR NATURAL RESOURCES	§
FOR THE STATE OF OKLAHOMA,	§
	§
	§
Plaintiff,	§ CASE NO. 05-CV-329-GKF-SAJ
	§
V.	§
	§
TYSON FOODS,	§
TYSON POULTRY, INC., TYSON CHICKEN, INC.,	§
COBB-VANTRESS, INC., AVIAGEN, INC.,	§
CAL-MAINE FOODS, INC.,	§
CAL-MAINE FARMS, INC., CARGILL, INC.,	§
CARGILL TURKEY PRODUCTS, LLC,	§
GEORGE'S, INC., GEORGE'S FARMS, INC.,	§
PETERSON FARMS, INC., SIMMONS FOODS, INC.	§
AND	§
WILLOWBROOK FOODS, INC.	§

Defendants.

EXPERT REPORT OF GORDON V. JOHNSON, Ph.D

1. Introduction

I, Gordon V. Johnson, grew up and lived on a small diversified farm in North Dakota until attending North Dakota State University, where I received a B.S. in agriculture majoring in Soil Science in 1963. I received a M.S. in Soil Science from the University of Nevada (Reno) in 1966 and a Ph. D in Soil Science from the University of Nebraska in 1969. From 1969 to 1977 I taught undergraduate

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and graduate classes, and conducted laboratory and field research in nutrient management at The University of Arizona. From 1977 to my retirement in 2004 I served as State Specialist in nutrient management for the Cooperative Extension Service at Oklahoma State University. In this capacity I provided educational programs in nutrient management to OSU County Extension Agents and Area Specialized Agents in Agronomy, and to State, District and Field technical staff of the Natural Resource Conservation Service (NRCS). I also developed, taught, and provided the exams for the statewide Nutrient Management Certification program for NRCS and for the Certified Crop Advisory program for Oklahoma. I have served in many regional and national professional organizations, received numerous achievement awards and published over 100 journal articles and fact sheets on nutrient management. From 1977 to 1990 I served as Director of the Soil, Water, and Forage Analytical Laboratories at OSU. I retired from OSU as Regents Professor of Soil Science and retain Emeriti status. Professional activities, including publications are identified in my attached curriculum vita.

2. <u>Professional Service</u>

a. I have been retained by the State of Oklahoma to evaluate:

i. The agronomic reasonableness of poultry litter application to land in the Illinois River Watershed (IRW);
ii. Behavior of phosphorus in soils and the environment.
iii. Phosphorus (P) as an essential macronutrient for plants.
iv. Nutrient Management.
v. Litter as a P nutrient source.
vi. STP and P management in the IRW.
vii. Soil amendments.
viii. NRCS 590 and P index use.
ix. STP and soluble P in field runoff.
x. Litter land application practices.

Agricultural practices are considered “agronomic” if the practices are essential to effective and economic soil management and crop production. As a result of my study, research, and teaching of nutrient management for agronomic crops, I am familiar with the soils and crops in the Illinois River Watershed. I have presented educational programs on nutrient management to land owners and operators of farms in the Illinois River Watershed and I am familiar with their practice of application of poultry litter to pasture and hay (forage) fields.
My rate of compensation is $110 per hour and I have billed a total of $81,573.07 to date. In rendering my opinions I am relying on my career professional experiences and scientific literature that I have reviewed and considered. I have testified in no other cases, either by trial or deposition, within the past four years.

3. Behavior of Phosphorus in Soils and the Environment.

a. Elemental P does not exist in nature, and is only a phenomenon of the laboratory and industry. White elemental P is a very reactive solid at room temperature and must be stored under water to prevent its reaction with oxygen (O_2). When exposed to the atmosphere it reacts violently with O_2. In nature P exists in combination with oxygen as the oxy-anion, orthophosphate (PO_4^{3-}), which is relatively stable, but bound with cations to form a variety of compounds. When hydrogen (H^+) is the only cation (laboratory situations), phosphate is present in the moderately strong phosphoric acid, H_3PO_4.

b. In soil solutions, PO_4^{3-} will react with whatever cations have the highest charge and are present in highest concentration. A deciding factor in what compound will eventually be formed by reacting with PO_4^{3-}, is the stability of the final compound formed. Thus, because aluminum phosphate ($AlPO_4$) and iron phosphate ($FePO_4$) are extremely stable, they are formed in soils acidic enough to cause aluminum (Al^{3+}) and iron (Fe^{3+}) to dissolve and be present to react with PO_4^{3-}. In soils where the pH is above 5.5 there is enough calcium (Ca^{2+}) present to form calcium phosphates, the least soluble (most stable) being rock phosphate or the mineral apatite ($Ca_5(PO_4)_3OH$). Rock phosphate is mined commercially from geologic marine deposits and is the primary raw material from which commercial fertilizer is manufactured.

c. Whenever fertilizer is added to soils the soluble phosphate will begin to react with calcium present in the soil to form various calcium phosphates of low solubility (plant availability) the final product (after about two years) being rock phosphate. In soils of pH suitable for plant growth (pH 5 to 8), the hydrogen (H^+) concentration in the soil solution is very low (1×10^{-5} to 1×10^{-8} mole/liter). These concentrations allow small amounts of PO_4^{3-} to be present in combination with H^+ in the form of $H_2PO_4^-$ and HPO_4^{2-}, the ionic forms of P taken up by plants.

d. Soils typically contain forms of organic and inorganic P in total amounts ranging from about 200 to 6,000 lb/acre. As plants grow they absorb inorganic water soluble P from the soil. Water soluble P removed by plants is repeatedly replenished by chemical transformation of less soluble forms of P in the soil to water soluble forms as a result of mass-balance, chemical equilibrium reactions.

4. Phosphorus (P) as an essential macronutrient for plants.

7. STP and P management in the IRW.

a. I have evaluated available information to determine if I can form an opinion on the agronomic P needs in the Illinois River Watershed using the STP correlations and calibrations discussed above. Based on the 2002 Census of Agriculture, 92.3 % of the total cropland is forage production (pasture or hay) for the counties within which the IRW resides in Oklahoma and Arkansas (2002 Census of Agriculture). Fescue and bermudagrass are the primary forages used for pasture and hay production. For these crops an STP value of 65 produces the maximum crop yield. Therefore, application of P to fields where soils are at or above an STP of 65 is not an agronomically reasonable practice. If the STP levels in IRW soils reach this maximum agronomic level, then those soils would not reasonably require additional P inputs from poultry litter.

b. I have reviewed the STP results from a Court supervised, land application of litter project in the Eucha-Spavinaw watershed in Eastern Oklahoma and Western Arkansas for 2006 and 2007. These soil tests were performed as a prerequisite to land application of poultry litter on managed for pasture and hay production. Integrators, identified in the database provided by the manager are Peterson Farms, Simmons, Tyson, Cobb-Vantress, Georges, Cargill, and Moark (see Excel data files). The test results would be typical for fields where poultry litter application occurs in Oklahoma and Arkansas. As such, they reflect STP for pasture soils in the IRW because of the similarity of land use, poultry operation and soil types in these contiguous watersheds. Of 617 observations in Arkansas, 601 (97%) had STP values in excess of 65 lb/acre and only 5 (< 1%) had values less than 40. The average STP (290 lb P/acre)for Arkansas samples was more than four times the agronomically reasonable STP of 65. For the 678 samples from Oklahoma the average STP was 165, 81 % had STP values greater than 65 and 91 % of the samples were greater than 40. The average STP was 2.5 times the agronomically reasonable STP of 65 (Figure 3). The sampling depth was set at 4 inches by the court and thus the calculated lb/acre STP is likely less than it would be for a 6-inch depth.

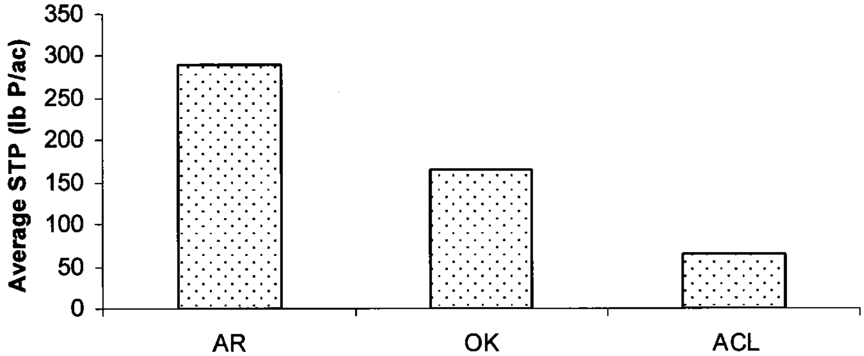

Figure 3. Average STP of samples from fields where poultry litter was applied in the Eucha – Spavinaw Watershed in 2006 and 2007 relative to the agronomic critical level of 65 (ACL).

c. A second data set of STP values for IRW soils from growers for defendants Georges and Tyson is shown in Table 2.

Table 2. Soil test N and P values for samples from Georges and Tyson growers.

	Georges			Tyson		
	Average N and P soil test values (lb/ac)					
Year	number	N	P	number	N	P
2000				35	13	66
2001	147	97	141	23	13	135
2002	63	74	354	47	13	268
2003	8	94	507	52	17	495
2004	34	63	763	12	35	752
2005	19	71	1166	4	14	1211
ALL	274	88	345	173	16	333
Range			19-1746			27-1529
Average STP of highest 1/4			792			667
Average STP of samples >65			395			364
% of samples with STP>65			85			90
% of samples with STP<40			6			3

For the period 2000 – 2005, the 173 values identified with Georges averaged 345 lb P/acre, over 5 times the ACL. Eighty five percent were greater than 65 and only 6 % of the samples had an STP less than 40. The upper 25% of these samples had an average STP of 792 (more than 10 times the ACL). The samples identified for Tyson growers averaged

333 (also 5 times the ACL), with 90 % above 65 and only 3 % less than 40. Additionally, the average available N was 16 for the samples associated with Tyson and 88 lb N/acre with samples associated with Georges, indicating a long practice of excess N and P input to these soils. Application of poultry litter sufficient to raise STP and available N to these levels is not a reasonable agronomic practice. Rather it indicates that such poultry litter application was disposal of waste. As a comparison, where land application of poultry waste is not common, as in 18 eastern Oklahoma counties where litter production is less than 1,000 tons per year, the average STP is 38 lb P/acre for the 2004-2006 period (OSU soil testing lab STP data and 2002 Census of Agriculture poultry production data, see Excel data files).

d. I have also examined results of soil tests from the public soil testing labs at the University of Arkansas and Oklahoma State University for the last three years data from counties within which the IRW resides (Benton and Washington counties in Arkansas and Adair, Cherokee, Delaware and Sequoyah counties in Oklahoma). These samples represent all samples collected within each county from fields identified for forage production. Therefore this collection of samples would be expected to include fields that have historically had P input from poultry litter, those with historic input of P from commercial fertilizer, and those that may be sampled for the first time to diagnose production problems. Commercial fertilizer is likely used when fields are not close to a source of poultry litter. Because commercial fertilizer-P is more costly than litter-P, farmers generally do not apply more than will be beneficial for the crop and STP values are generally maintained near 65 (as indicated in (6d) above, by the average STP of 38 for 18 eastern Oklahoma counties where annual litter production is less than 1,000 tons.) To the extent commercial fertilizer is used instead of poultry litter-P in these counties, the county average STP will be less than what is reported for fields receiving poultry litter-P (paragraphs (6b) and (6c) above). Nevertheless, even for these county-wide results, the average STP was 402 lb P/acre and 90 % of the 6558 samples from Arkansas counties from 2005 to 2007 had STP values in excess of 65 lb/acre, and 96 % had values greater than 40 lb/acre, the 95% crop yield sufficiency level (Arkansas soil testing lab). Results from the Oklahoma counties for 2005 to 2007 had an average STP of 102 lb P/acre and showed that of 4,216 samples, 78 % had values greater than 65 and 83 % had values greater than 40 lb/acre (OSU Soil, Water and Forage Analytical Laboratory, annual summaries).

e. The Arkansas legislature recently passed new laws that went into effect on January 1, 2006. These laws require STP analysis before poultry litter can be land applied. The effect of this legislation became evident in review of soil test results for Benton and Washington counties. From 2000 to 2005, the average number of soil samples tested each year associated with forage production, was 299 and 223 for Benton and Washington counties, and the average STP values, although more than double the ACL of 65, were 174 and 140, respectively. The total number of samples increased dramatically in 2006 and 2007, to an annual average of 1088 for Benton County and 1803 for Washington County. The respective STP values also greatly increased and averaged 453 and 426 respectively. The upper 25 % of samples averaged over 900 lb P/acre, with the highest 17 samples exceeding 3,000 lb P/acre. Phosphorus deficiency (i.e., less than 65 STP) was indicated for only 5.0 % of the samples for Benton County and 8.3 % of the samples for Washington County. Although the results for these two years still include samples outside of the IRW and samples where commercial fertilizer is the source of nutrients, the dramatic change in number of samples is a result of newly required tests where poultry litter has been, and was intended to be, applied. The dramatic increase in average STP values, which are more than six times the adequate level for crops, and the presence of such astronomically high soil test results, is a clear indication excessive poultry litter P has been applied in the past and fertilizer P is no longer needed for the vast majority (93 %) of these fields.

f. I have reviewed the Arkansas Natural Resources Commission annual reports that record STP values associated with comprehensive nutrient management plans developed for land application of litter.

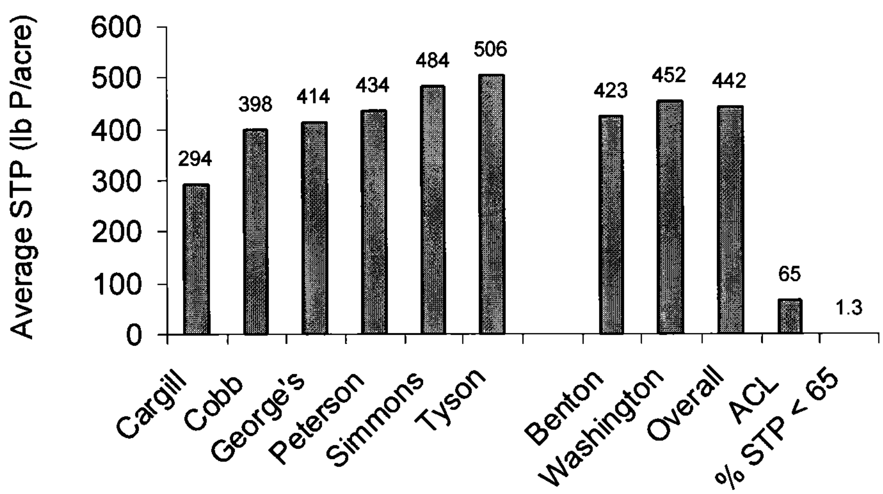

Figure 4. Soil test P values from Arkansas Natural Resources Commission registry for litter management, 2007. Integrators were identified only for Benton County.

This data represents STP values for fields where poultry litter waste was being land applied in the IRW in 2007 by growers associated with the indicated integrators. Overall there were 224 STP values expressed as "Avg. P Level". Each "Avg. P Level" often representing several hundred acres. For example, an "Avg. P Level" of 539 lb P/acre was identified with 886 acres associated with the integrator Cargill. Similarly, an "Avg. P Level" of 761 lb P/acre was associated with 500 acres for a Tyson grower(s).

g. I have also reviewed recent studies by the USDA that have examined the capacity of counties to assimilate nutrients from animal manure. Using animal census data from 1982 and 1997 these USDA studies have shown that nationally over 50 % of the on-farm excess N and P is from poultry production (Gollehon, et al., 2001) An estimated 97 % of the animal manure produced and land applied in the IRW is poultry litter (from 2002 Census of Agriculture livestock data). Using 1997 data, the USDA concluded categorically that between 75 -100 % of the on-farm N and P from animal manure generated in Washington and Benton Counties in Arkansas and Delaware County in Oklahoma was in excess of the farms' ability to reasonably assimilate the nutrients as fertilizer. Adair, Cherokee and Sequoyah counties in Oklahoma were categorized as 50 – 75 % in excess of the farms' ability to agronomically assimilate the nutrients (Confined Animal Production and Manure Nutrients. USDA 2001. pg 25-26; Fig 25-26.). This 1997 "excess" of these nutrients is now likely to have become even greater because poultry production has increased since 1997 and IRW soils have become more nutrient saturated. The government studies did not consider available soil nutrients identified by current soil tests, and thus are conservative estimates of the P excesses.

h. A recent study relating N and P inputs from fertilizer and manure, removal by harvested crops, and the balance of deficiency or excess was conducted in Arkansas (Slaton, et al., 2004). Separating the state into nine districts, the five-year study concluded that poultry litter accounted for 96 % of the total manure-derived N, P, and K in the state. They also concluded that although forage uptake of P is high for areas of western Arkansas where poultry litter production is greatest, "nutrients removed by forage crops are usually fed or recycled on-farm rather than exported outside the district boundaries". They further stated that "...most soils used for warm-and cool-season grass production in Arkansas already have adequate Mehlich 3-extractable P levels that do not require additional P fertilization for forage production..." With regard to the balance of inputs and removal of P they concluded "The greatest excess of N and P exists in District 1 ..." within which Benton and Washington counties are included. They also concluded that "The results from this assessment may help reinforce the thought that current nutrient application strategies in western Arkansas are not sustainable without the danger of creating and/or exacerbating water quality issues from excessive nutrients. Transport of excessive N and P contained in poultry litter outside of the central and western Arkansas districts that have restricted land area available for nutrient application is needed if the current poultry production levels are to be maintained." Similar to the USDA study in (g.) above, they did not consider soil contributions to provide crop P when they calculated the balance between manure inputs and crop removal and, consequently, the statements of excess P are greatly underestimated.

i. Based upon my review of the above STP values and reports of nutrient excesses, it is clear that land application of poultry litter has led to excessive P build-up in land within the IRW. The need for additional widespread land application of poultry litter as a P fertilizer does not exist. Almost all continued land application of poultry litter within the IRW should be judged as a waste disposal practice rather than fertilization. Given the low percentage of fields with STP values less than 65 and the large amount of litter produced in the IRW, most of the litter should not be applied within the IRW. Very few forage fields in the IRW would reasonably require additional application of poultry litter under good agronomic practices.

8. <u>Soil amendments</u>.

a. Amending soils is a practice where materials are added to soils to correct conditions that have been identified as limiting normal soil productivity. Under State law, only materials that are proven to correct these limiting conditions may be licensed as soil amendments (Oklahoma Soil Amendment Act). Unmanipulated animal manures are specifically excluded from the definition of soil amendments . Additionally, to be effective, soil amendments must typically be incorporated into the soil by tilling and used to correct an identified production-limiting, soil property. Land application of poultry litter to pasture and hay land in the IRW usually involves only surface spreading without tilling. Consequently, land application of litter in the watershed does not qualify as a soil amending practice and it is unlikely that significant non-fertilizer benefits could be obtained.

9. <u>NRCS 590 and P index use</u>.

a. I have examined the NRCS Code 590 guidelines and the use of phosphorus indexes (PI) in the Southern Region of the US. Most of the states have 590 tables identifying applicable animal waste application rates based upon "environmental threshold" STP levels. States that do not have such tables suggest use of a PI instead.

b. The widespread use of these guidelines, in the US as well as the Southern Region, should not be interpreted as a sign of widespread scientific support, as is sometimes suggested, but rather as a result of a large NRCS presence in every state.

c. The 590 documents typically identify limits for commercial fertilizer inputs on the basis of agronomic critical levels (ACL) from long-standing, scientifically based STP calibrations. These ACL tables are used by NRCS to identify the limits for subsidizing (cost-share) fertilizer inputs for conservation practices by farmers receiving government assistance. NRCS has no enforcement authority except to deny assistance when guidelines are not followed.

d. The 590 documents typically include separate tables to identify animal waste application rates for "Non-Nutrient Limited watersheds" and "Nutrient Limited Watersheds". Application rates in these tables are not science-based, but rather the result of opinions on what may or may not cause environmental impact. These opinions have produced tables identifying animal waste land application rates related to N crop requirement and STP environmental threshold levels. Nitrogen crop requirements are scientifically based, incorporating crop N content and projected yield levels. Table STP values are not scientifically based and the levels used have not been related (calibrated) to actual soluble P in runoff or reaching surface water bodies. The Oklahoma NRCS 590 table for Non-Nutrient Limited Watersheds, for example, uses five categories of STP from "Low" to "Severe". The low category applies to STP values from 0 – 65 and allows animal waste rates to meet crop N requirements. STP values for other categories have no rational basis and range from 66 to 400 lb P/acre. The table for Nutrient Limited Watersheds is similar, with the exception that the upper limit STP value is 300 lb P/acre.

e. Implementation of both the 590 guidelines and PIs is based on the premise that relative risk to the environment is evaluated by the tool, and animal waste application rates governed accordingly. While much scientific effort has gone into calculating relative risk values, the acceptable maximum risk has not been identified. Furthermore, these tools have failed to adequately recognize that for P Nutrient Limited Watersheds, such as the IRW, the minimum risk is achieved by not applying P after the STP reaches 65. Use of the Arkansas PI has been defended because "A significant positive relationship was found between the average SRP

(soluble reactive P) concentration in runoff … and the P index…" in a recent Arkansas study (DeLaune, et al., 2004). The same research stated that "In contrast, poor relationships were observed between soil test P and SRP concentrations in runoff on each farm (Table 5). This can be attributed to the overwhelming influence of soluble P applied to the plots." Thus, even though STP may be excessive and contribute harmful levels of soluble P to surface waters, it is not considered independent of soluble P in the litter. Instead, the contribution of STP as a P source component in the PI is minimal because the PI risk calculations always include a component for soluble P in the litter.
Use of these tools are only a short-term solution to disposal of excess waste, and in the long-term waste P input must match agronomic use, as expressed by scientists of the Southern Region of the US, (Maguire et al.).

f. The philosophy of litter applications after STP levels have exceeded the ACL is to provide crop N requirements. However, when litter applications are made according to the NRCS 590 Code guidelines in Oklahoma and the Arkansas PI, neither litter N content nor soil test N are measured and used as a part of the comprehensive nutrient plans.

10. <u>STP and soluble P in field runoff.</u>

a. I have evaluated scientific literature related to STP and soluble P in runoff to form an opinion on the impact to surface water quality as a result of continued litter application based on phosphorus indexes, or other rules or guidelines, which allow litter application in excess of agronomic P requirements. Surface water runoff is a commonly accepted mechanism for P transport over the landscape (Figure 4 from Zhang et al., 2002).

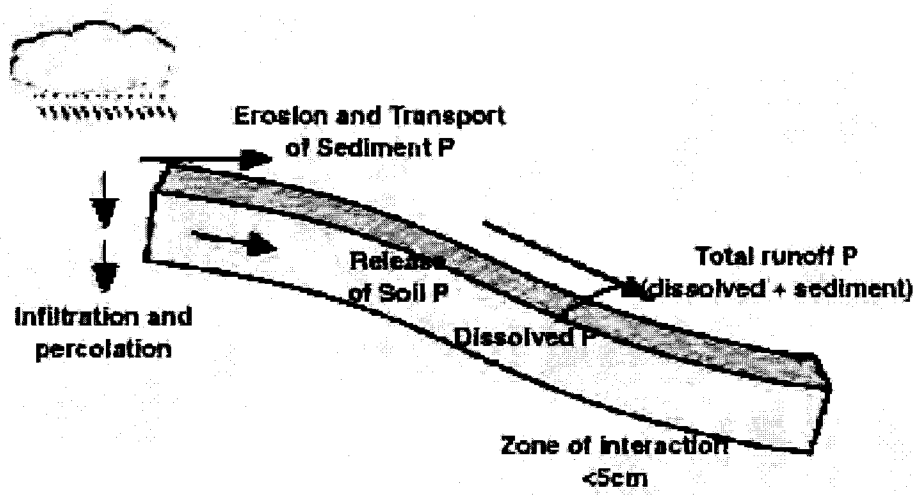

Figure 4. Mechanisms of phosphorus transport over landscape: erosion and runoff.

Gordon V. Johnson

Gordon V. Johnson

Subscribed and sworn to me by Gordon V. Johnson on the 13th day of May, 2008.

Signature

T J Payne

Printed Name

Notary Public, Payne County, Oklahoma

OFFICIAL SEAL
T J PAYNE
NOTARY PUBLIC OKLAHOMA
PAYNE COUNTY
COMM. EXP. 04-18-2011
COMM. NO. 07003848

My Commission Expires: 04-18-2011